TVS-CV-81-112

Surveys of the Commercial Vehicles and Truck Tires Used in the Toronto Area

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Research Division

TVS-CV-81-112

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ABSTRACT

On site investigations of commercial vehicle accidents have been conducted in the Toronto area during the last two winters. These surveys have been intended to assure the relevance of research projects concerned with commercial vehicle safety. Further data were required to put the accident data in context, leading to the two surveys described in this report. The first survey determined the make-up of the commercial vehicle population based on axle configuration, body style and weight class. The second survey sampled tire tread design used on the traction or drive axles of trucks for comparison with those tread types most often involved in jackknife or other skidding accidents.

The surveys described the present commercial vehicle and traction tire type populations and they demonstrated significant differences between weight classes as well as between straight trucks, tractor-semitrailers, truck trailers and A- and B-trains. The most common heavy truck by far is a three-axle tractor pulling a tandem-axle semitrailer, usually with van-type body. The larger combinations make up less than 5% of the heavy truck population, with B-trains now nearly as popular as A-trains.

The "cross rib" traction tire, though very common on straight trucks, is used on only 25% of articulated trucks: "mud and snow" type treads make up 65% of this group, and 85% of A- and B-train tires.

ACKNOWLEDGEMENTS

These surveys were conducted to assist on-the-scene investigations of commercial vehicle accidents. They were carried out under Project 31608 of the Policy Planning and Research Division with Frank Snelgrove as project leader. The assistance of Ross Critelli of the Program Development Office is acknowledged for providing traffic volume data.

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1/ INTRODUCTION

1.1/ Population Survey

All too frequently, commercial vehicle (CV) accidents provide spectacular proof of the dangers of highway travel. Because of the vehicles' size, such accidents inevitably can cause considerable disruption to traffic and attract wide public attention. As part of an ongoing research program to improve the safety of commercial vehicles on Ontario highways, the Research and Development Branch has been undertaking on-site accident investigations in the Toronto area. In addition, all Ontario Provincial Police (O.P.P.) reports for CV accidents in the study area are being collected and analysed. It is expected that this accident survey will provide hard data to ensure the relevance of further research projects by demonstrating which of various human, vehicle and environmental factors can lead to accidents.

To establish absolute and comparative accident rates for different vehicle types, statistics are required on the CV traffic currently using Toronto region highways. For this reason, a survey was undertaken to gather data on the numbers and types of CVs in use. These data were specifically analysed by axle configuration (straight trucks, tractor-semitrailers, trains, etc.), body type (van, tanker, etc.), and gross vehicle weight. Hence, these elements could be considered as factors in CV accidents so that the classes of vehicles over-represented could be examined in detail to determine the reasons.

1.2/ Tire Survey

An early analysis of the accidents involving jackknifing articulated vehicles and skidding accidents in general suggested that tire tread design, particularly on a truck's drive axles, may be a causative factor. However, this could only be confirmed by surveying the tread types in use on all trucks in the Toronto area -- hence, the survey reported here. The survey was conducted by observing the traction tire tread patterns on heavy CVs passing through the weight inspection stations (weigh scales) on King's Highways in the Toronto area. Tread type distributions were determined for different types of CVs for comparison with accident statistics.

2/ POPULATION SURVEY

2.1/ Method

The survey was intended to provide a picture of the types of trucks in use within the accident investigation area. Since the survey included only accidents occurring within the jurisdiction of the O.P.P. (i.e., King's Highways), it is the traffic on these highways that is primarily of interest. Figure 1 shows the highways included within the first survey period (November 1979 to March 1980). The second period (January to April 1981) extended the coverage southwest to the Burlington Skyway within Burlington O.P.P. jurisdiction.

These highways are primarily high-volume urban and inter-urban arterial roads carrying all types of truck traffic. For simplicity, the population survey was conducted at a single location -- all seven eastbound lanes of Highway 401 just west of Keele St. as viewed from the third floor of the Ministry of Transportation and Communications Building. The location provided an excellent view of the traffic because of its height. No trucks were hidden by passing vehicles or by traffic in the westbound lanes. The westbound lanes were not included in the survey because the commercial vehicle traffic was too great to try to account for every vehicle in both directions (this section of the 401 carries more traffic than any other in Ontario). Eastbound lanes were chosen for these reasons:

- the up-hill grade on the eastbound lanes caused the commercial vehicles to travel slower, allowing more time for observation;
- the eastbound lanes were further away from the observation point, thereby increasing the field of view; and
- westbound trucks approaching the observation point were obscured by the Keele Street overpass, greatly reducing observation time.

The survey covered a total of eight and three-quarter hours which was spread over one work week and classified a total of 5454 trucks (Table 1). The count was broken down into 15-min intervals to show which periods of the day had the heaviest commercial vehicle traffic. This also allowed comparisons with total traffic to determine the fraction of all traffic made up of commercial vehicles.

Table 1/ Periods Covered in 1981 Commerical Vehicle Population Survey

Date	Time	Interval Period Nos.*
Wed. February 11	10:30 to 11:30	42-46
Wed. February 11	15:00 to 16:25	60-65.7
Thu. February 12	12:00 to 13:30	48-54
Thu. February 12	13:45 to 15:00	55-60
Fri. February 13	7:45 to 8:50	31-35.3
Mon. February 16	8:45 to 9:45	35-39
Tue. February 17	16:00 to 17:30	64-70

*Interval 1 begins at midnight; Interval 2 at 00:15, etc.

Every commercial vehicle with an estimated gross weight exceeding 5000 kg that passed the survey location during these periods was recorded by a black-and-white Sony video camera and recorder. Basically, this included every vehicle with dual tires on its drive axles. At the same time, its axle configuration and body style were read onto the video tape's voice track. A zoom lens ensured that the traffic in the eastbound lanes was clearly visible. A start/stop trigger on the camera allowed the tape to be stopped when there were no commercial vehicles passing, providing more efficient tape utilization.

The tapes were later played back and each CV was classified according to its axle configuration, body style, and weight class. A total of 21 configurations were defined and categorized into five broad groups: straight trucks, tractor-semitrailers, truck/full trailers, A-trains (tractor-semitrailer/full trailers), and B-trains (tractor-semitrailer-semitrailers) as shown in Figure 2. Figure 2 also defines the codes used to describe vehicle axle arrangements.

Twenty different body styles (including "other") were used for body style classification, as shown in Figure 3. Because the vehicles were in motion, it was impossible to precisely establish their individual gross weight rating. Therefore, each was classified as light, medium or heavy, as indicated in Table 2. All but two trucks with three or more axles were categorised as heavy trucks.

Table 2/ Weight Groups

No.	Weight Group	Approximate Mass (kg)
1	Light	5 000 to 9 000
2	Medium	9 000 to 14 000
3	Heavy	> 14 000

The recorder was stopped at each vehicle and its configuration, body style and weight classes noted on a form, per Figure 4. The tapes were checked twice to ensure accuracy.

The 5454 CVs classified by this survey were felt to be sufficient for a realistic sample of CVs in use in the accident survey area, particularly as the sample was taken at a relatively central location within this area on the busiest section of highway. However, it was felt that local variability was significant in same areas. For example, the location of petroleum pipeline terminals leads to much higher tanker traffic on routes to and from them than one might observe elsewhere. Therefore, smaller surveys were conducted at two other locations (as part of the tire survey) to investigate this. Video taping was unnecessary for these surveys due to the lower traffic volumes encountered.

2.2/ Results

2.2.1./ Body Styles

The survey indicated that the most popular body style or type of cargo area for a CV was the van (a fully-enclosed cargo space), including refrigerated and heated vans. Table 3 shows that these accounted for 60.4% of heavy trucks, 78% of medium trucks, and 91.4% of light trucks. They dominated the body style classification, contributing 69.9% of all CVs, the next most popular body style (the box) making up only 9.6% of the total. The further breakdown into refrigerated and standard vans

should be treated with some caution as external inspection at speed made this detailed classification difficult. Any van with equipment mounted high up its front face was assumed to be refrigerated. A similar difficulty may also have caused some container trailers to be classed as van trailers or flat-beds (for the chassis only) and some livestock trailers to be classified as vans. The box bodies included dumps (i.e., boxes equipped with lifts). Trucks or trailers hauling containers used as disposal bins at construction sites were classified as disposal units.

The only other body style commonly observed was the flat-bed, comprising 8.2% of the CV population. No other style exceeded 2.5% of all CVs, though 4.6% of heavy trucks were tractors running bobtail (without semi-trailers) and 3.8% were tankers. Tankers were thought to be under-represented as major tanker terminals 4 km north at Keele and Finch were normally approached from the east up the Allen Expressway and from the west up Highway 400, so tankers using those terminals would not pass Keele St. on Highway 401. This is discussed further in Section 2.2.5.

Table 3/ Body Styles

Code #	Body Style	Heavy Trucks #	Heavy Trucks %	Medium Trucks #	Medium Trucks %	Light Trucks #	Light Trucks %	All Trucks #	All Trucks %
1	Power Unit	141	4.6					141	2.6
2	Flat-bed	315	10.4	121	7.1	13	1.8	449	8.2
3	Container	25	0.8					25	0.5
4	Box	295	9.7	183	10.8	48	6.7	526	9.6
6	Tanker	117	3.9	14	0.8			131	2.4
7	Bulk cargo, Self-dumping	14	0.5					14	0.3
8	School Bus			48	2.8			48	0.9
9	Intercity bus	112	3.7					112	2.1
10	City bus	1	0.0					1	-
11	Car Transporter	60	2.0					60	1.1
12	Concrete Mixer	37	1.2					37	0.7
13	Van	1812	59.6	1267	74.5	634	88.8	3713	68.1
15	Van-Refrigerated	23	0.8	59	3.5	19	2.7	101	1.9
16	Livestock carrier	1	0.0					1	-
18	Low-bed	41	1.4					41	0.8
20	Disposal Unit	37	1.2	8	0.5			45	0.8
99	Other								
	a) Crane	5	0.2					5	0.1
	b) Pole train	2	0.1					2	0.0
	c) Hydro truck with lift	2	0.1					2	0.0
TOTALS		3040		1700		714		5454	

2.2.2/ Axle Configurations

The classification of the trucks surveyed by weight class and axle configuration is given in Table 4. By definition, almost all light CVs and essentially all medium CVs were two-axle straight-trucks, accounting for 44% of all vehicles surveyed. Obviously, it is the heavy-duty vehicles that require more than two axles to allow the carriage of heavy goods. Only 7.2% of heavy vehicles have two axles. Figure 5 shows the breakdown of these vehicles by number of axles. The peak for five-axle vehicles is largely the result of the popularity of the 3s2, a three-axle tractor pulling a two-axle semitrailer, contributing 98.5% of the 41.3% of heavy CVs with five axles. Figure 6 shows the most common axle configurations and body styles for all surveyed vehicles.

Axle configurations were divided into five groups, depending on unit composition. The groups are: straight trucks, tractor-semitrailers, straight trucks pulling full trailers (truck-trailers), A-trains (tractor-semitrailer-full trailers), and B-trains (tractor-semitrailer-semitrailers). These groups are shown in Table 5; straight trucks being most popular (57%), followed by tractor-semitrailers. Of tractors pulling semitrailers, 29% have two axles and 71% have three axles. The vehicle trains are relatively rare, each of these groups making up only about 0.5% of the total. Interestingly, the B-train is nearly as common as the A-train, despite being a relatively recent development.

Table 6 shows a similar breakdown for heavy truck body types for each axle group. This was not necessary for other weight classes as all were straight trucks. Straight trucks are only one-third as popular as tractor-semitrailers in this weight class. The van tractor-semitrailer is the dominant vehicle comprising 72.7% of all tractor-semitrailers and 53.6% of all heavy CVs. The 3s2 van is easily the most popular single axle/ body style combination, making up 29.7% of all heavy CVs and 73% of all 3s2's.

Body types are more balanced among straight trucks, with only 23.5% vans; bobtail tractors (19.5%) being the next most common. Among A-trains, box and van bodies were commmon, while 50% of B-trains were flat-beds. Van B-trains are relatively rare as vans are conventionally unloaded from the

rear at a loading dock and the fifth wheel at the back of the B-train's lead semitrailer has made such use more difficult than for A-trains. The majority of truck-trailers had box bodies (55.6%), commonly being aggregate-hauling dump trucks.

Table 4/ Axle Configurations

	Vehicle Type	Heavy Trucks	Medium Trucks	Light Trucks	All Trucks
1	2 axles	220	1698	714	2632
2	3 axles	457	2		459
3	2s1	141			141
4	2s2	505			505
5	3s1	8			8
6	3s2	1238			1238
7	3s3	323			323
8	2-2	2			2
9	2-3	2			2
10	3-3	8			8
11	2s1-2	4			4
12	2s2-2	1			1
13	2s2-3	3			3
14	3s2-2	2			2
15	3s2-3	15			15
16	3s3s2	13			13
17	3s3s3	1			1
18	Other Trucks				
	a) 2s3	5			5
	b) 2-1-1-1	3			3
	c) 3-1-1-1	1			1
	d) 3-1-1	1			1
	e) 3s1-2	1			1
	f) 4-4	1			1
	g) 3s2-4	3			3
	h) 3s1-3	1			1
	i) 3s1s2	1			1
	j) 3-2	1			1
	k) 5 axles	1			1
19	4 axles	35			35
20	3s4	19			19
21	3-4	13			13
22	3s2s2	11			11
TOTALS		3040	1700	714	5454

Table 5/ Axle Groups for All Commercial Vehicles

Straight Trucks		Tractor-Semitrailers		Truck-Trailers	
01 2 axles	2632	03 2s1	141	08 2-2	2
02 3 axles	459	04 2s2	505	09 2-3	2
19 4 axles	35	05 3s1	8	10 3-3	8
18 5 axles	1	06 3s2	1238	18 4-4	1
18 3-1-1-1	1	07 3s3	323	18 3-2	1
18 3-1-1	1	18 2s3	5	21 3-4	13
18 2-1-1-1	3	19 3s4	19		
TOTALS	3132		2239		27

A-Trains		B-Trains	
11 2s1-2	4	16 3s3s2	13
12 2s2-2	1	17 3s3s3	1
13 2s2-3	3	18 3s1s2	1
14 3s2-2	2	3s2s2	11
15 3s2-3	15		
18 3s1-3	1		26
18 3s2-4	3		
18 3s1-2	1		
TOTALS	30		

Table 6/ Body Types and Axle Groups for Heavy Commercial Vehicles

Body Style	Straight-Trucks	Tractor Semitrailers	Truck-trailer	A-trains	B-trains
Power Unit Only	141				
Flat-bed	83	209	8	2	13
Box	101	165	15	10	4
Tanker	20	86		6	5
Inter-City Bus	112				
City Bus	1				
Van	169	1629	1	9	4
Van-Refrigerated	13	10			
Crane	5				
Hydro truck	2				
Disposal Unit	34		3		
Concrete Mixer	37				
Container		22		3	
Bulk cargo-self dumping		14			
Car Transporter		60			
Livestock Carrier (bi-level)		1			
Low-bed		41			
Pole train		2			
TOTALS	718	2239	27	30	26

2.2.3/ Air-Lift Axles

A 3s3 configuration is a three-axle tractor pulling a three-axle semi-trailer. The three-axle trailer can carry a greater load than a two-axle trailer. For example, a dual axle can carry up to 19 100 kg, whereas a three-axle group, having a wider spread, can carry up to 28 600 kg. A three-axle semitrailer, in Ontario, benefits (in terms of payload) from the widest possible axle spread. However, increasing axle spread increases tire wear when cornering (Figure 7). To reduce this, many trailers (and some multi-axle trucks) have one or more air-liftable axles. These are usually near the centre of the trailer to give maximum weight allowance but, when lifted, they minimize trailer tire scrub during cornering.

As part of this survey, 3s3 vehicles were checked to see whether the front trailer axle was air-liftable and whether or not it was positioned up, or down (Table 7). Findings showed that 28.4% had the lead axle lifted, even though not all three-axle trailers are equipped with liftable axles (e.g., low-bed trailers). Eliminating the low-bed trailers increased the fraction of trailers with a lifted axle to 29.9%. Unfortunately, there was no means of establishing how many of these trailers were fully loaded as 3s3's and, hence, possibly overloaded.

A similar analysis of four-axle straight trucks showed 17 with an axle raised and 18 with all axles down. As the majority of such trucks have an air-liftable axle, and are probably empty for at least 50% of their trips, these results appear reasonable.

Table 7/ 3s3 Truck Air-Lifted Axles

	Wheels up	Wheels down
02 Flat-Bed	36	69
04 Box	13	53
06 Tanker	6	17
07 Bulk Cargo (self dumping)	0	5
13 Van	37	70
15 Refrigerated Van	0	1
03 Container	0	1
18 Low-Bed	0	15
Totals	92	231
Percentage	28.5%	71.5%

2.2.4/ Commercial Vehicles as a Fraction of Total Traffic

A survey conducted on June 28, 1978, at the same location (but for all lanes in both directions) determined the hourly CV and total traffic count for the 24-h period.

These 1981 traffic survey data were analysed to generate similar results over the limited survey period using all eastbound traffic. Total traffic count for all eastbound lanes, for every 15-min period of the survey was requested from R. Critelli of the Program Development Office. Data supplied came from the Keele St. Permanent Counting Station. Data for the driving lane of the collectors were from one year earlier, as 1981 data were unavailable. The totaled volumes are shown in Table 8.

The current survey data spanned every working day of the week and had to be adjusted to represent continuous traffic in the nine hours from 8:00 to 17:00. Table 8 also lists the CV counts for each 15-min period, which were combined with the total volumes to obtain the CV volume percentage every 15 min. This is shown in Figure 8, together with averaged hourly values for 1981 and 1978 results. The present survey found a higher fraction of CVs early in the morning (compared with 1978) but from 10:00 onwards the fraction fell below the earlier value.

The percentage (P) of commercial vehicles over a 24-h period for the 1981 survey was calculated as follows.

$$P = \frac{\text{Total CV Volume, 1981, 8:00-17:00}}{\text{Total Traffic, 1981, 8:00-17:00}} \div \frac{\text{Total CV Volume 1978, 8:00-17:00}}{\text{Total Traffic, 1978, 8:00-17:00}}$$

$$\times \text{ (\% CVs, 1978, 24 h)}$$

The percentage of CVs in a 24-h period, on this basis, decreased from 8.82% in 1978 (28 June) to 7.47% in 1981 (11-16 February). The changes may be due to variations through the year, the effects of business growth or recession, or daily variability, as well as reflecting an annual trend. This particular result should be treated with some caution due to the assumptions on which it is based.

Table 8/ Traffic Counts of Commercial and Total Vehicles on Hwy 401 (Eastbound) at Keele Street

Time	Monday Feb 16		Tuesday Feb 17		Wednesday Feb 11		Thursday Feb 12		Friday Feb 13	
	Total Veh.	Comm. Veh.	Total Veh.	Comm. Veh.	Total Veh.	Comm. Veh.	Total Veh.	Comm. Veh.	Total Veh.	Comm. Veh.
7:30- 7:45										
7:45- 8:00									2 200	185
8:00- 8:15									2 110	150
8:15- 8:30									2 100	195
8:30- 8:45									1 890	191
8:45- 9:00	2 160	204							1 860	81
9:00- 9:15	1 880	206								
9:15- 9:30	1 660	250								
9:30- 9:45	1 610	211								
9:45-10:00			No Count Taken							
10:00-10:15			No Count Taken							
10:15-10:30			No Count Taken							
10:30-10:45					1 230	174				
10:45-11:00					1 260	145				
11:00-11:15					1 170	146				
11:15-11:30					1 270	140				
11:30-11:45			No Count Taken							
11:45-12:00			No Count Taken							
12:00-12:15							1 230	156		
12:15-12:30							1 180	152		
12:30-12:45							1 180	124		
12:45-13:00							1 190	140		
13:00-13:15							1 130	155		
13:15-13:30							1 280	118		
13:30-13:45							1 320			
13:45-14:00							1 360	215		
14:00-14:15							1 340	118		
14:15-14:30							1 460	112		
14:30-14:45							1 420	162		
14:45-15:00							1 480	139		
15:00-15:15					1 430	164				
15:15-15:30					1 470	149				
15:30-15:45					1 660	118				
15:45-16:00					1 980	157				
16:00-16:15			2 170	138	2 080	102				
16:15-16:30			2 360	131	2 280	39*				
16:30-16:45			2 460	153						
16:45-17:00			2 580	137						
17:00-17:15			2 420	109						
17:15-17:30			2 440	90						
17:30-17:45										
17:45-18:00										
TOTALS	10 270	871	14 430	758	15 790	1334	15 570	1691	10 160	800

* Incomplete counts, less than 15 minutes

2.2.5/ Comparison with Mini-Surveys

The primary truck population survey described in this report sampled 5454 CVs passing Keele St. on eastbound Highway 401. Three additional smaller surveys at other locations were also analysed for CV axle configuration, body type, and weight class to evaluate variability in these data across the Toronto region.

Eight surveys of tire usage were conducted at the local truck inspection stations (see Chapter 3) shown in Figure 1. The vehicles surveyed for tire type were also classified in this way (though bias was introduced by the sampling method as only CVs stopped for weighing) and a total of 1716 vehicles were accumulated. The two other small surveys were also conducted during these tire surveys. The first counted all CV traffic in the eastbound lanes of Highway 401 at Streetsville Road during the tire survey (totalling 500 CVs). A further 467 were sampled comprising all CV traffic, both north and southbound combined, on Highway 400 at the inspection stations north of Toronto.

Table 9 presents the numbers of heavy CVs in each configuration group, as well as the light and medium straight trucks, in each survey. No light and medium CVs were observed during the tire survey, as only heavy vehicles were surveyed. The large number counted in the main survey was consistent with its location inside Metropolitan Toronto where greater local delivery is to be expected. The three on-highway surveys gave very consistent numbers of heavy straight trucks and tractor-semitrailers. The fractions of larger combinations showed more variation, the relative rarity of such vehicles and their use by fewer operators accounting for this. The pattern of tanker traffic (often A- or B-trains) mentioned in Section 2.2 may also be a factor -- A-trains varying from 1.0% to 2.3% and B-trains from 0.7% to 2.6% of all heavy vehicles. In general, it was concluded that truck-trailers, A-trains, and B-trains are almost equally common, with A-trains being the most common configuration of the three.

Table 9/ Configuration Groups in Four Surveys

Configuration Group	401 E.B at Keele St.	401 E.B. At Streetsville	Hwy 400	Truck Tire Population Survey*
	No. (%)	No. (%)	No. (%)	No. (%)
Straight trucks	718 (23.6)	86 (20.4)	72 (20.9)	175 (10.3)
Tractor Semi-Trailers	2239 (73.7)	311 (73.7)	251 (72.8)	1425 (83.0)
Truck-trailers	27 (0.9)	14 (3.3)	5 (1.4)	27 (1.6)
A-Trains	30 (1.0)	8 (1.9)	8 (2.3)	56 (3.3)
B-trains	26 (0.9)	3 (0.7)	9 (2.6)	33 (1.9)
Totals	3040	422	345	1716
Medium and Light trucks	2414 (79.4)	78 (18.5)	122 (35.4)	0 (0.0)
Totals	5454	500	467	1716

* Including counts from eight weigh stations in Toronto.

The distribution of heavy truck body styles listed in Table 10 makes the considerable variation between the surveys clear. The remarkably high fraction of box bodies (33.9%) on 401 eastbound at Streetsville Road is due entirely to the large number of dump trucks hauling aggregate into Toronto from the major gravel pits to the west. This correspondingly reduced the percentages of other body styles at that location below "typical" levels. Flat-beds (22.3%) and tankers (7.5%) were most common on Highway 400, because it is a major route for lumber hauled from the north into Toronto (on flat-beds), and for petroleum tankers carrying their cargo north.

Few bobtail tractors were tallied at the inspection stations as they never required weighing. Similarly, buses are absent as they are not required to stop for inspection. Car transporters cannot be overloaded and consequently were rarely stopped, or included in this survey; and, of course, vehicles that were clearly empty were not stopped. These factors introduced some bias in this particular survey.

Table 10/ Body Styles of Heavy Trucks in Various Areas of Toronto

Body Style	401 E.B. at Keele St.	401 E.B at Streetsville Road	Hwy 400	Truck Tire Population Survey*
	No. (%)	No. (%)	No. (%)	No. (%)
Power Unit Only	141 (4.6)	9 (2.1)	8 (2.3)	9 (0.5)
Flat-bed	315 (10.4)	57 (13.5)	77 (22.3)	289 (16.8)
Box	295 (9.7)	143 (33.9)	38 (11.0)	282 (16.4)
Tanker	117 (3.8)	14 (3.3)	26 (7.5)	145 (8.4)
Inter-City Bus	112 (3.7)	6 (1.4)	4 (1.2)	
Van	1812 (59.6)	149 (35.3)	140 (40.6)	831 (48.4)
Van-Refrigerated	23 (0.8)	3 (0.7)	6 (1.7)	29 (1.7)
Crane	5 (0.2)	1 (0.2)		1 (0.1)
Hydro Truck	2 (0.1)			
Concrete Mixer	37 (1.2)	2 (0.5)	1 (0.3)	1 (0.1)
Container	25 (1.0)	5 (1.2)	1 (0.3)	11 (0.6)
Bulkcargo-Self dumping	14 (0.5)	3 (0.7)	6 (1.7)	53 (3.1)
Car Transporter	60 (2.0)	23 (5.5)	8 (2.3)	12 (0.7)
Livestock Carrier (bi-level)	1 (0.0)			13 (0.8)
Low-bed	41 (1.3)	2 (0.5)	8 (2.3)	30 (1.7)
Pole train	2 (0.1)			
City Bus	1 (0.0)			
Livestock carrier (single level)		3 (0.7)		
Disposal unit	37 (1.2)	2 (0.5)	22 (6.4)	10 (0.6)
Total	3040	422	345	1716

*Done at eight inspection stations in Toronto.

3/ TRACTION TIRE SURVEY

3.1/ Tire Types

The tires on the traction axles of heavy trucks were surveyed during the brief period of a few seconds in which they were stationary at truck inspection stations. For this reason, it was only possible to classify them according to tread pattern and not size, manufacturer, model, air pressure, tread depth, or any other factor that may affect their traction capability. The tread pattern was classified into the seven types shown in Figure 9, as follows.

1/ Lug

This is a heavy-duty tire with large lugs on the shoulders and major angular grooves throughout. It is usually intended for vehicles with a major off-highway requirement. Designs include:

- General - Super All Grip,
- Goodrich - Extra Traction,
- Uniroyal - Fleetmaster Deep-Lug.

2/ Cross Rib

This tire design has a centre rib, often quite wide, running around the tire. The primary tread pattern comprises partial lateral grooves or "cross ribs" running from the tire's shoulders towards its centre. Other, shallower grooves or sipes may be included. It is usually a bias ply tire. Makes with this tread pattern include:

- Firestone - Power Drive,
- Goodrich - Traction Express Custom,
- Goodyear - Custom Cross Rib Hi-Miler,
- Uniroyal - Fleetmaster Super Lug.

3/ Mud and Snow (M+S)

These tires have no continuous rib running around the tire. Circumferential and full lateral grooves break the tread into a large number of tread blocks. They are commonly, but not always, radial tires. The following makes fall into this category;

- Firestone - Transteel Traction Drive,
- Goodyear - Unisteel TD Radial,
- Michelin - XM+S.

4/ Bias Ply Rib

The tread pattern of the bias ply tire is like that of the radial rib tire, though the type of construction makes its shoulder profile a little less rounded. Models include:

- Goodrich - Silvertown Extra Miler, and
- Goodyear - Hi-Miler SXT.

5/ Radial Rib

The rib tire's tread pattern is similar to that of most summer car tires -- major grooves are spaced across the tread and run circumferentially around the tire, usually with sipes or less deep grooves between them. Radial tires with this tread pattern include:

- Firestone - Transteel Rib Radial,
- Goodrich - Milesaver Radial Steel HDR,
- Goodyear - Unisteel II Radial,
- Michelin - XZA,
- Uniroyal - Steelmaster Radial R-2.

6/ Crossbar

This tread design has no circumferential grooves, but instead has many transverse grooves across the full width of the tire. This pattern occurs on some retreaded tires.

7/ Shoulder Rib

Usually on a bias ply tire, the tread has only two major circumferential grooves, one near each shoulder. Further grooves and sipes are usually shallower. Examples of this tread are:

- Firestone - Transport 1,
- Goodyear - Super Hi-Miler,
- Uniroyal - Fleetmaster Triple Tread.

3.2/ Survey Method

The survey was conducted at the eight truck inspection (weigh) stations in the Toronto area (shown in Figure 1) at the times shown in Table 11. This allowed a realistic sampling of heavy trucks for the entire region, as the stations covered all major highway entries and exits from Toronto. They were the only points at which a good cross-section of vehicles were stationary, which was required for determining tire type. As Table 11 shows, a total of 1716 heavy trucks were sampled, the number at each station depending on both the traffic volume and time available.

Table 11/ Tire Survey Locations and Periods

Inspection Station	Date	Time	No. of Trucks
400 Southbound	Tue. March 24	1:00 to 16:15	95
400 Northbound	Tue. March 24	9:08 to 12:32	109
401 Eastbound at Streetsville Rd.	Fri. March 27	8:50 to 11:45	200
401 Westbound at Streetsville Rd.	Wed. March 18	13:45 to 21:50	447
Queen Elizabeth Way Eastbound at Lorne Park	Thu. March 26	9:10 to 12:50	300
Queen Elizabeth Way Westbound at Oakville	Mon. March 23	12:05 to 15:00	206
401 Eastbound at Whitby	Wed. March 25	8:55 to 12:00	235
401 Westbound at Bowmanville	Wed. March 25	12:55 to 16.15	124
Total Number of Trucks			1716

The survey was unable to account for every heavy CV passing the inspection stations during the survey period. Generally, only those stopped for weighing could be checked for tire type. Obviously empty trucks (bobtail tractors, flat-beds) were excluded. This also affected the types of other trucks which were surveyed. Tankers were common on Highway 400 between Barrie and Toronto both north and southbound. However, northbound they were usually loaded and stopped for weighing, while southbound they were usually empty, allowing them to use the bypass lane without stopping. Thus, tankers made up 26 of 109 northbound trucks, but only 1 of 95 southbound. Buses are not required to enter inspection stations and were excluded. Other types (such as car transports) that could not exceed weight limits even when fully loaded, were also rarely stopped. A few car transporters were, however, included as their length sometimes prevented them using the left lane by-passing the weight scale. Similarly, some bobtail tractors were included as they were forced to stop by the other traffic.

As each vehicle stopped at the weigh scale, the observer noted the tire tread pattern of each of the tires on the right side its drive or

traction axles (the left side was not usually visible) (Figure 9). Of course, all the traction tires of a vehicle were not always identical but the intent was to determine the tire types used by a vehicle. In keeping with this, the left tires were assumed to be the same as those on the right side, and each tire type was counted as the fraction it made up of all traction axles tires. For example, if a truck had two dual-tired drive axles (i.e., four tires on the right side), each accounted for a quarter its tire type. If the truck had two M+S tires and two cross rib tires on these axles, it was recorded as having 0.5 M+S and 0.5 cross rib tires. The axle configuration (Figure 2) and body style (Figure 3) were also recorded, and the tire types were totalled for all vehicles sampled according to axle configuration group (straight truck, tractor-semitrailer, etc.).

3.3/ Results

Table 12 lists the total and percentage of tire types for all five axle configuration groups; Figure 10 shows the percentages in bar-chart form.

Clearly the M+S tread was the dominant tread design, with the cross rib design next. In combination, they account for 89.4% of all traction axle tires. Of course, this was not true of truck tires in general. The majority of front axle and trailer axles tires were of the rib design (radial, bias, or shoulder), accounting for perhaps 50% of all truck tires. However, operators have a strong tendency to mount more aggressive tread designs on traction axles, presumably to aid drive traction either on or off the highway. Radial designs appear to constitute about two-thirds of all traction axle tires.

The dominance of the M+S was absent in straight trucks. Here, the cross rib tire had more than half the market (54.6%), while M+S represented less than one-third (29.0%). As opposed to the case of articulated vehicles, straight trucks are more often owner-operated or part of a small company. This may be a factor in tire choice -- radial tires are certainly more expensive per tire.

The major configuration group was that of tractor-semitrailers, and its tire usage was close to that of all heavy trucks.

Truck-trailers closely followed the pattern of straight trucks in tire use, the cross rib type being most popular. This is hardly surprising, as such a vehicle has only to unhitch its trailer to become a straight truck. The A- and B-trains show similar traction tire use, with M+S tires dominant at 84.8%, and most of the remainder using cross rib tires.

These results were reasonably consistent between survey locations -- at least as consistent as the distribution of axle configurations and body styles. Despite the biases introduced by the sampling procedure, the results are a good indication of the types of traction tires currently in use in the Toronto area.

Table 12/ Tire Type Usage

Configuration	Tire Type	Tire Count	%	Total
Straight trucks	M+S	50.75	29.0	175
	Cross rib	95.5	54.6	
	Radial rib	13.5	7.7	
	Bias rib	2.0	1.1	
	Shoulder rib	4.25	2.4	
	Lug	7.0	4.0	
	Crossbar	2.0	1.1	
Tractor-semitrailers	M+S	906.5	63.6	1425
	Cross rib	370.75	26.0	
	Radial rib	81.75	5.7	
	Bias rib	1.0	0.1	
	Shoulder rib	43.5	3.1	
	Lug	7.0	0.5	
	Cross bar	14.5	1.0	
Truck-trailers	M+S	8.5	31.5	27
	Cross rib	16.0	59.3	
	Radial rib	0.5	1.9	
	Shoulder rib	1.0	3.7	
	Lug	1.0	3.7	
A-trains	M+S	47.5	84.8	56
	Cross rib	6.0	10.7	
	Radial rib	2.5	4.5	
B-trains	M+S	28.0	84.8	33
	Cross rib	4.5	13.6	
	Radial rib	0.5	1.5	
All	M+S	1041.25	60.7	1716
	Cross rib	492.75	28.7	
	Radial rib	98.75	5.8	
	Bias rib	3.0	0.2	
	Shoulder rib	48.75	2.8	
	Lug	15.0	0.9	
	Crossbar	16.5	1.0	

4/ CONCLUSIONS

1/ The commercial vehicle (CV) population and heavy truck tire surveys of the Toronto area described above have generated much useful data that can be applied to the analysis and understanding of factors involved in commercial vehicle accidents.

2/ The dominant CV body study on the King's Highways in this area was the van (68%). The box (including dump) (9.6%) and flat-bed (8.2%) being the other major body styles.

3/ Light and medium trucks made up a large portion (44.2%) of the CV population surveyed.

4/ The most common heavy truck in use by far was the 3s2 van tractor-semi-trailer (29.7%).

5/ The large vehicle combinations (truck-trailer, A- and B-trains) appear to make up only 2.7% of the heavy CV population. Despite its later development, the B-train was nearly as popular as the A-train.

6/ Commerical vehicles made up about 7.5% of traffic volume on Highway 401, a small decease from the 8.8% recorded in a more accurate count carried out in 1978.

7/ Nearly 90% of heavy trucks used M+S or cross rib tires on their traction axles, though normal rib tires were usually used on other axles.

8/ The cross rib tire was used on 55% of heavy straight trucks and truck-trailers, while for the majority of heavy CVs (the other articulated vehicles), only 25% were so equipped and 65% used the M+S tire.

9/ The large A- and B-trains were usually equipped with radial M+S tires (85%) on the traction axles.

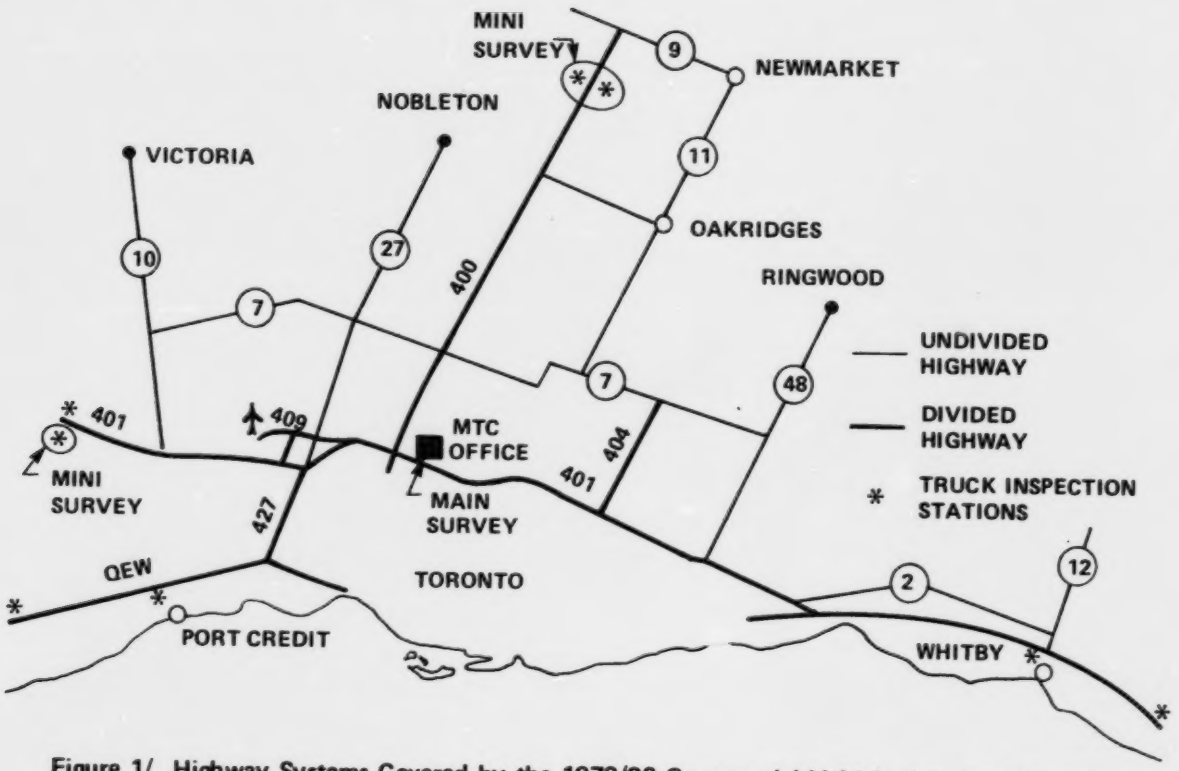


Figure 1/ Highway Systems Covered by the 1979/80 Commercial Vehicle Accident Survey

Survey Code	Axle Code	Description
		STRAIGHT TRUCKS
01	2	4-wheel truck or bus, 2 axles
02	3	6-wheel truck or bus, 3 axles
19	4	8-wheel truck, 4 axles
		TRACTOR SEMITRAILERS
03	2s1	4-wheel tractor and 2-wheel semitrailer, 3 axles
04	2s2	4-wheel tractor and tandem semitrailer, 4 axles
05	3s1	6-wheel tractor and 2-wheel semitrailer, 4 axles
06	3s2	6-wheel tractor and tandem semitrailer, 5 axles
07	3s3	6-wheel tractor and 3-axle semitrailer, 6 axles
20	3s4	6-wheel tractor and 4-axle semitrailer, 7 axles
		TRUCK-TRAILERS
08	2-2	4-wheel truck and 4-wheel full trailer, 4 axles
09	2-3	4-wheel truck and 6-wheel full trailer, 5 axles
10	3-3	6-wheel truck and 6-wheel full trailer, 6 axles
21	3-4	6-wheel truck and 8-wheel full trailer, 7 axles
		A-TRAINS
11	2s1-2	4-wheel tractor, 2-wheel semitrailer and 4-wheel full trailer, 5 axles
12	2s2-2	4-wheel tractor, tandem semitrailer and 4-wheel full trailer, 6 axles
13	2s2-3	4-wheel tractor, tandem semitrailer and 6-wheel full trailer, 7 axles
14	3s2-2	6-wheel tractor, tandem semitrailer and 4-wheel full trailer, 7 axles
15	3s2-3	6-wheel tractor, tandem semitrailer and 6-wheel full trailer, 8 axles
		B-TRAINS
16	3s3s2	8-axle B-train
17	3s3s3	9-axle B- train
22	3s2s2	7-axle B-train
18		**ANY OTHER AXLE CONFIGURATIONS**

Figure 2/ Axle Configuration Groups

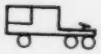
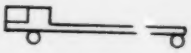
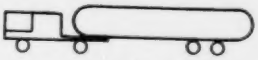
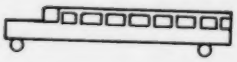
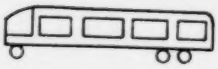
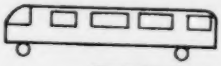
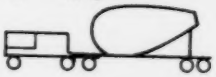
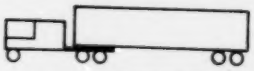
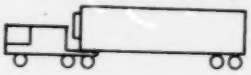
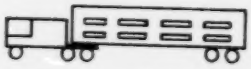
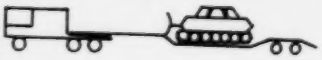
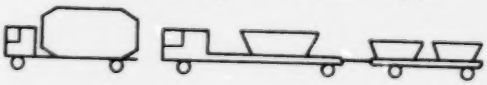
CODE No.	BODY STYLE		DESCRIPTION
01	Power Unit Only		Bobtail for pulling semitrailers
02	Flat Bed		Truck with platform
03	Container		Body frame carrying intermodal shipping containers
04	Box		Four-sided, open top cargo area (includes dump trucks)
06	Tanker		Truck which hauls liquid products
07	Bulk Cargo Self Dumping		Truck which unloads through the funnels at the base of the cargo area
08	School Bus		
09	Inter City Bus		
10	City Bus		
11	Car Transporter		
12	Concrete Mixer		
13	Van		Truck with closed cargo space
15	Van-Refrigerated		Van with refrigerating unit at front of cargo area
16	Live Stock Carrier		Cargo area for hauling livestock
18	Low Bed		Truck for hauling heavy vehicles
20	Disposal Unit		Truck for hauling disposable materials
99	Other a) Crane		
	b) Pole Train		
	c) Hydro Truck with Lift		

Figure 3/ Body Style Groups

COMMERCIAL VEHICLE SURVEY

LOCATION: Eastbound 401 at Keele St.

DATE: Friday Feb. 13 1981

OBSERVER: Tom Wilhelm

VEHICLE NUMBER	DAY OF WEEK	TIME	SIZE	CONFIG. NUMBER	BODY NUMBER	COMMENTS
1	5	(31)	3	2	2	
2			2	1	13	7:45 a.m. (Table 1)
3			2	1	13	
4			3	2	1	
5			3	4	13	
6			1	1	13	
7			2	1	4	
8			2	1	13	
9			3	4	13	
10			1	1	13	
11			2	1	13	HEAVY TRUCK (Table 2)
12			3	4	13	
13			2	1	4	
14			3	2	9	3s2 TRACTOR SEMITRAILER (Figure 2)
15			3	2	9	
16			(3)	(6)	(13)	VAN (Figure 3)
17			2	1	4	
18			1	1	13	
19			3	4	13	
20			3	6	13	
21			3	4	13	
22			3	1	13	
23			3	6	6	
24			2	1	9	
25			3	6	6	
26			2	1	4	with pony trailer
27			3	4	2	
28			3	6	13	
29			2	1	13	
30			2	1	13	
31			3	4	13	
32			2	1	13	
33			3	6	6	
34			2	1	4	
35			3	5	13	
36			3	2	4	
37			3	6	13	
38			3	7	2	
39			3	4	13	
40			2	1	8	
41			3	4	13	
42			3	6	13	
43			3	2	2	
44			2	1	2	
45			3	4	13	
46			2	1	13	
47			3	2	4	
48			2	1	13	
49			3	2	13	
50			3	5	13	

Figure 4/ Classification Form

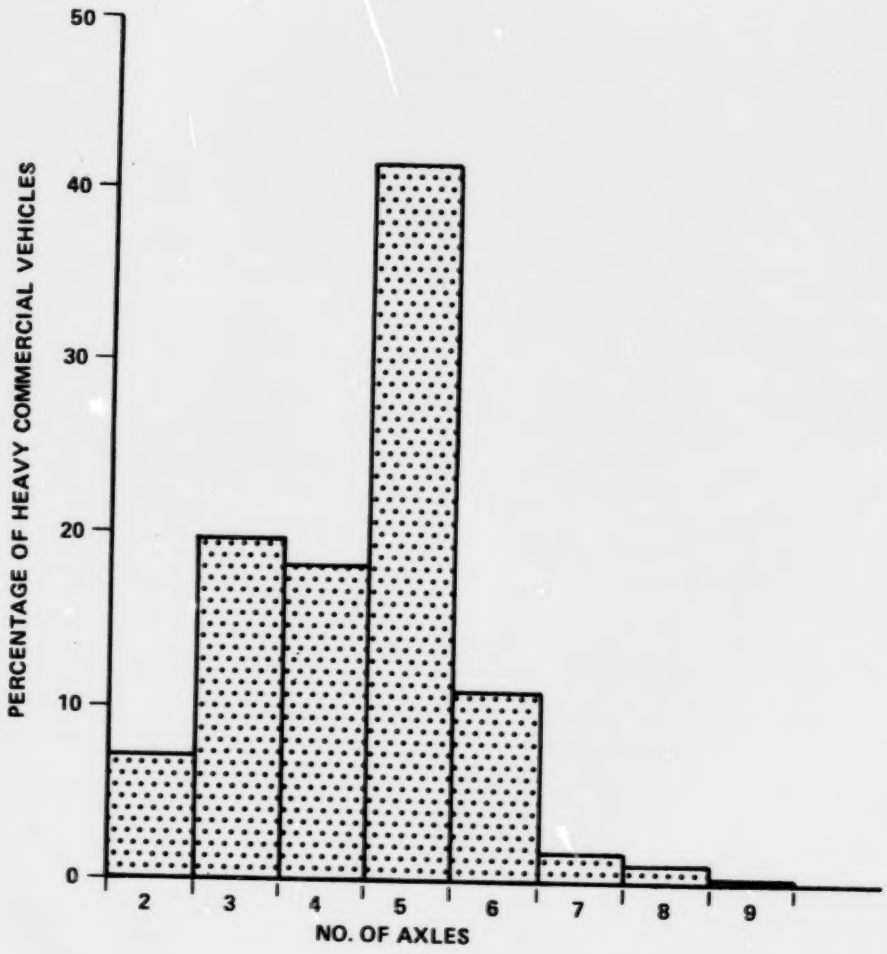


Figure 5/ Number of Axles of Heavy Vehicles

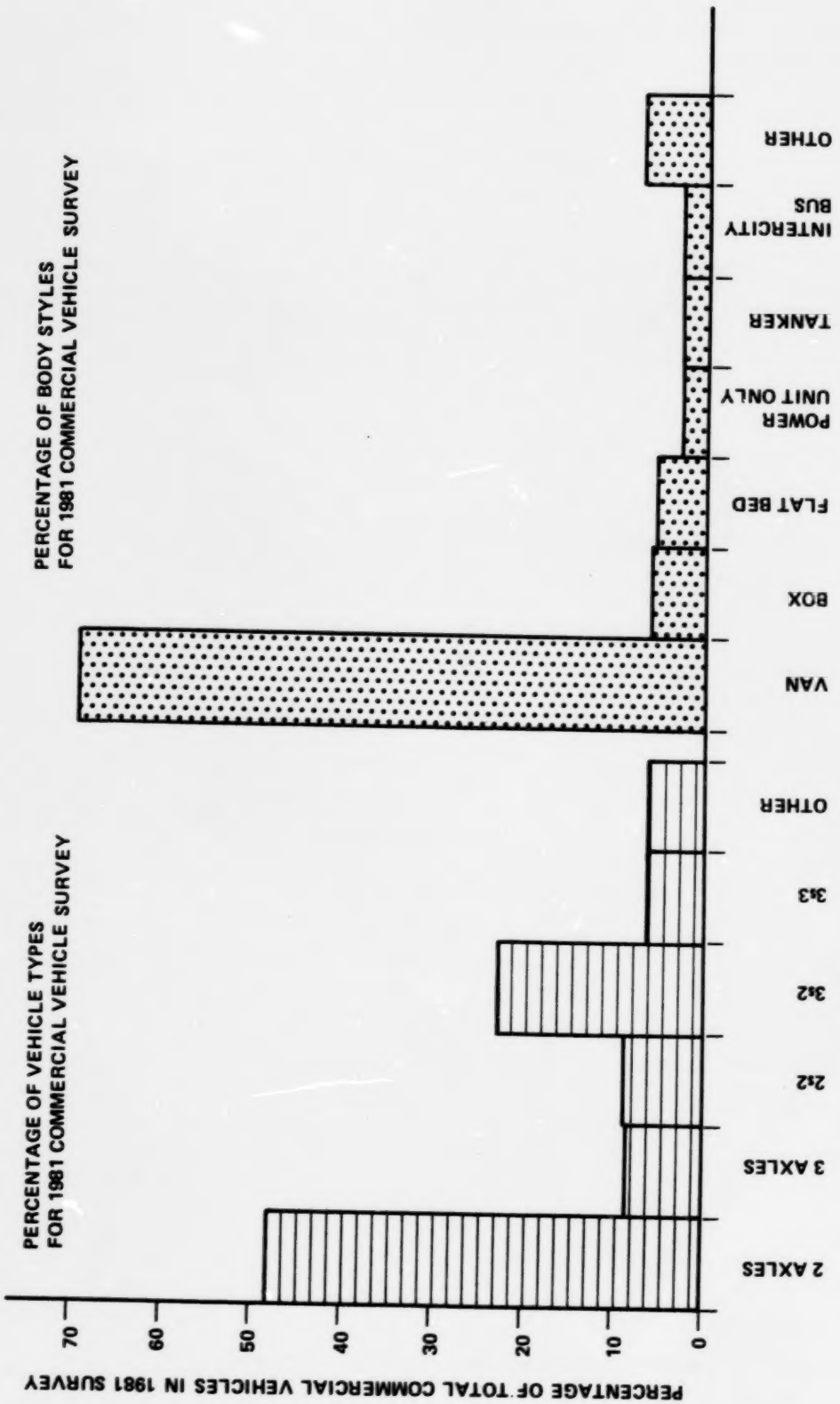


Figure 6/ Percentages of Axle Configuration and Body Styles for All Commercial Vehicles

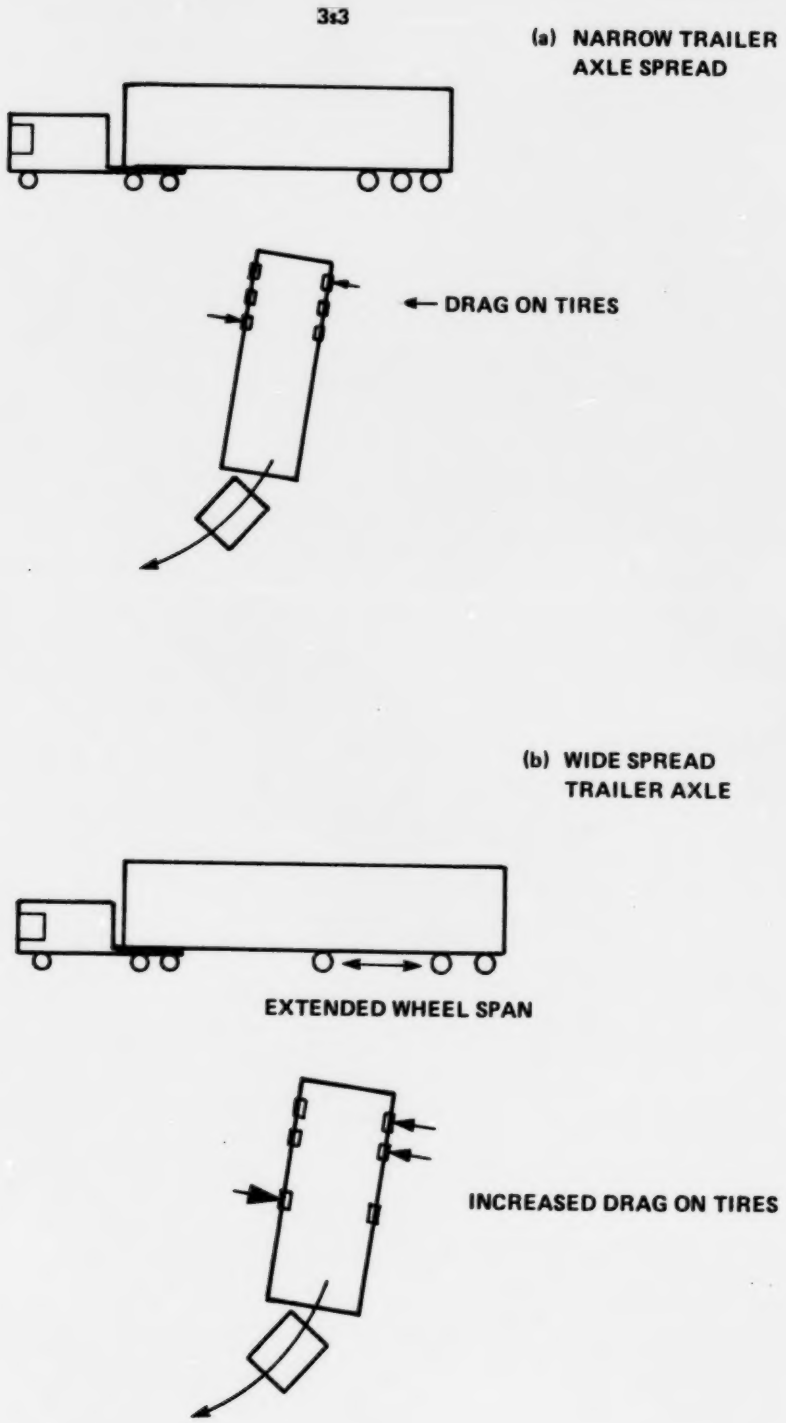


Figure 7/ Effect of Axle Spread on Tire Wear

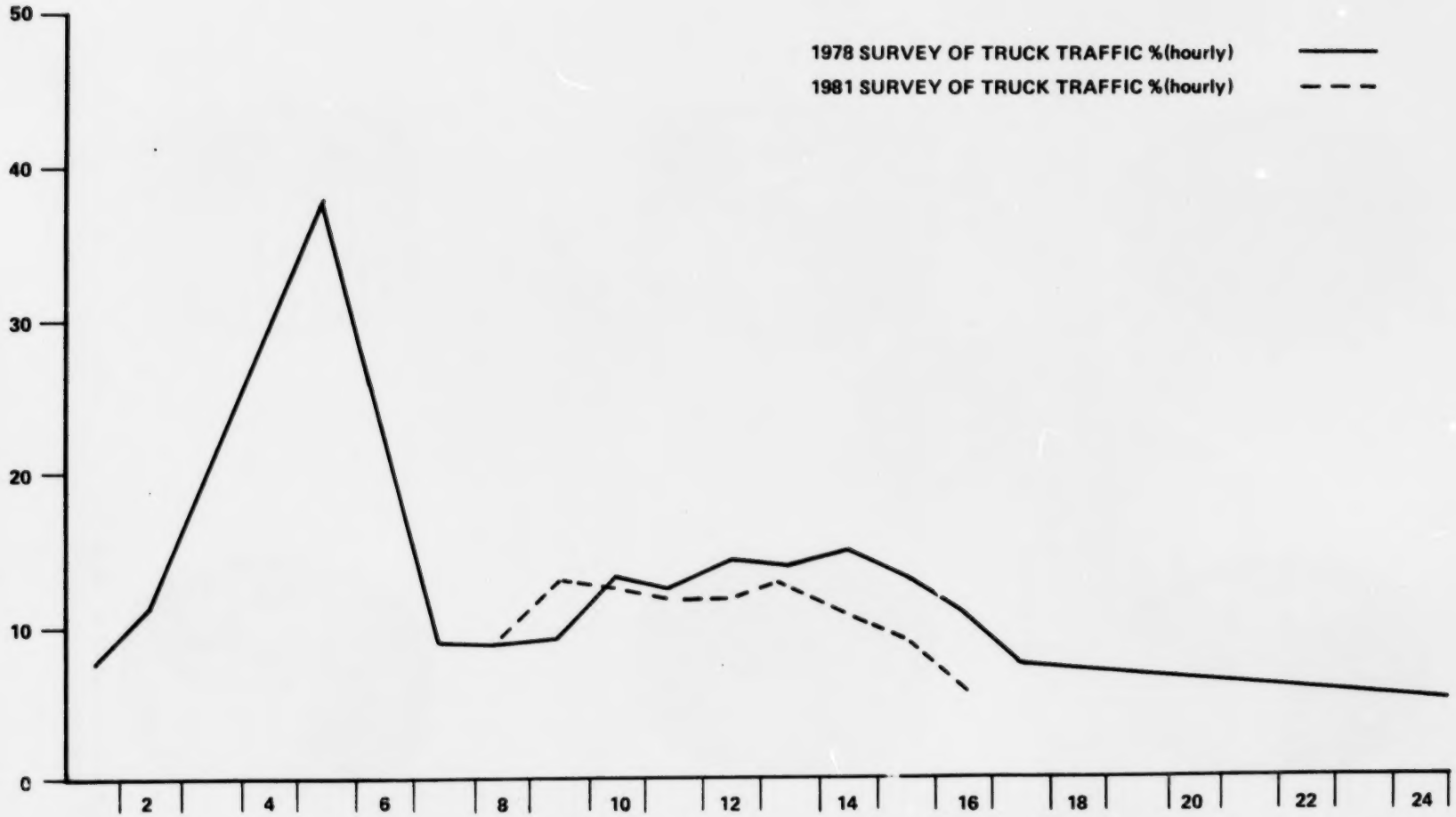
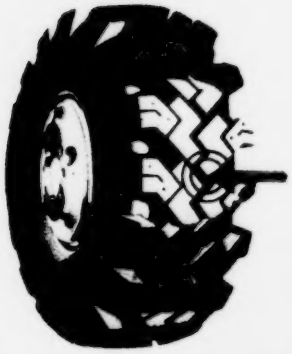


Figure 8/ Hourly Distribution of Truck Traffic

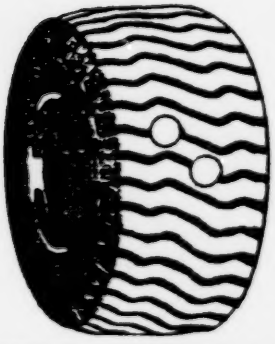


1/ LUG – A HEAVY-DUTY TIRE WITH DEEP, WIDE GROOVES FOR OFF-ROAD USE

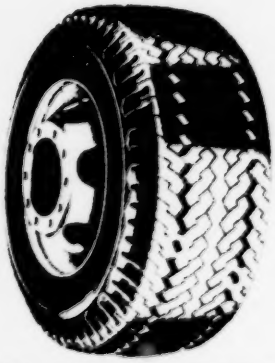
2/ CROSS-RIB TIRE – HORIZONTAL RIBS EXTENDING TOWARD THE CENTER OF THE TIRE (NEARLY ALWAYS BIAS PLY)

3/ MUD AND SNOW – VERTICAL AND HORIZONTAL TREAD (NEARLY ALWAYS RADIAL)

4 & 5/ RADIAL AND BIAS PLY RIB TIRE – VERTICAL TREAD



6/ CROSSBAR – HORIZONTAL TREAD EXTENDING ACROSS COMPLETE WIDTH OF TIRE



7/ BIAS – 2 SHOULDER RIB-DOMINANT TREAD ON SHOULDER OF TIRE

Figure 9/ Tire Tread Patterns

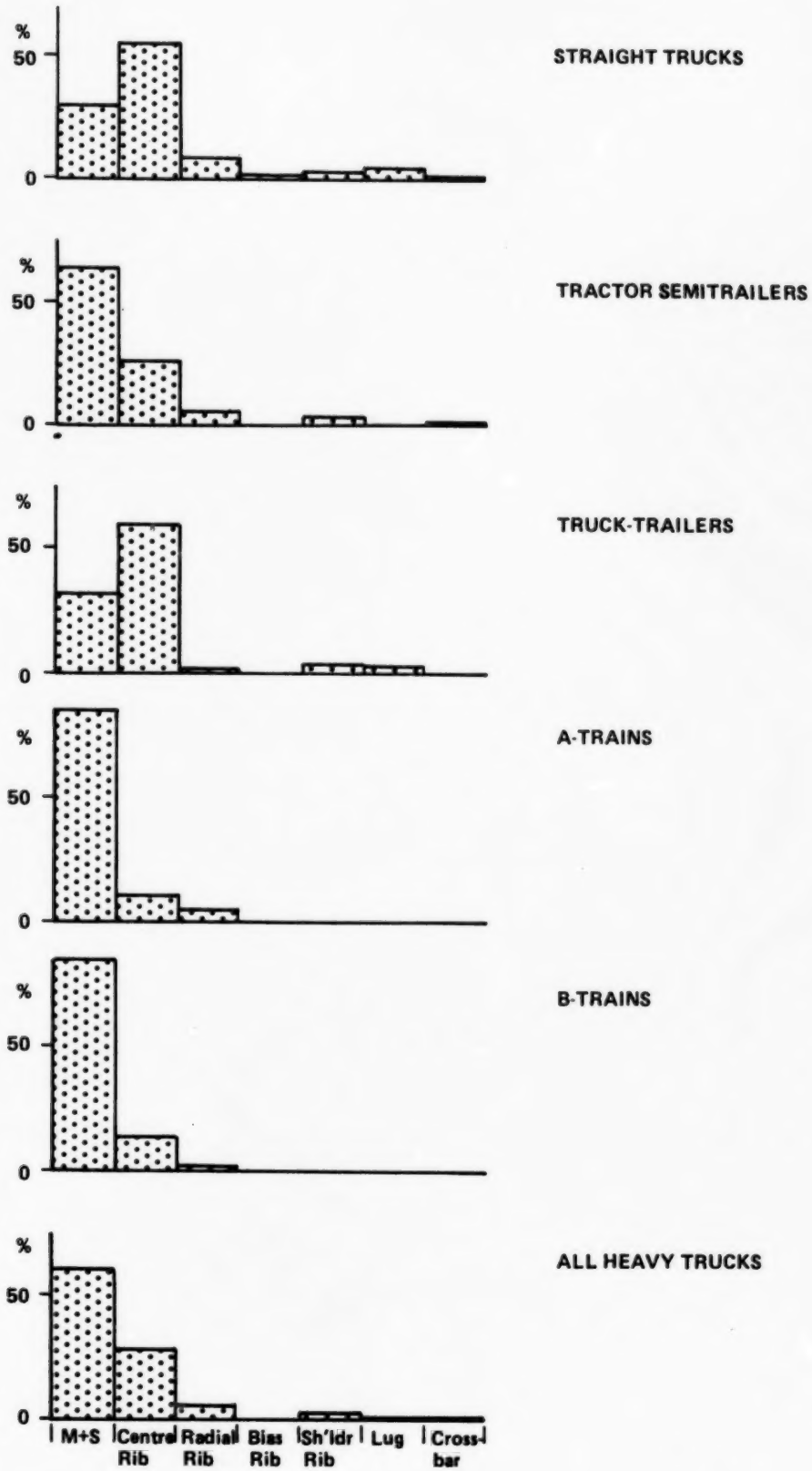


Figure 10/ Traction Tire Usage for Heavy Trucks